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Letter to the Editor

What ICRP advice applies to DU?☆

1. Introduction

We welcome this special issue of the Journal that aims to set out the hard science behind the controversy of health effects of depleted uranium in munitions. As concern has grown over this matter, we have received a number of enquiries as to whether ICRP has issued advice on DU. ICRP has not issued specific advice, but we believe that existing recommendations and general guidelines have some relevance. We would like to take the opportunity of this special issue of the Journal to explain this position.

For some years, ICRP Committee 2 has had a work programme to develop dose coefficients (committed effective dose per unit intake) for intakes by inhalation and ingestion for both workers and members of the public. That programme has included uranium compounds. However, we should point out that the recommendations of ICRP relate only to the radiation dose from uranium. There are many situations where the chemical toxicity of uranium is limiting. This may be especially important for DU, since it has a lower specific activity than natural uranium and contains only minute traces of decay products. The reader is referred to WHO (2001) for advice on chemical toxicity.

ICRP advice is restricted to the modelling of dose from intake. There is no ICRP advice on exposure scenarios. All main routes of exposure and the likely amounts of intake need to be assessed for various exposure scenarios. Exposure scenarios for internal and external exposures, both on the battlefield and due to subsequent environmental contamination are being considered by the Royal Society (2001, in preparation).

2. Modelling doses from intakes

ICRP has developed a series of models to assess organ doses and effective dose from intake of radionuclides. Two routes of intake are considered: ingestion and inhalation.

☆ This letter is not an official ICRP statement; the authors alone are responsible for its contents

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The current model describing the gastrointestinal tract is based on the biological model developed by Eve (1966) and has been applied for in previous advice on intakes by workers (ICRP, 1979). The model describing the human respiratory tract has undergone considerable revision and extension since that time. The revision resulted from increased knowledge of the anatomy and physiology of the respiratory tract and of the deposition, clearance and biological effects of inhaled radioactive particles. The model provides the flexibility needed to calculate doses to the respiratory tract for a wide range of exposure conditions and materials. It is described in ICRP Publication 66 (1994a) and has been implemented in computer programs, such as LUDEP (Birchall et al., 1991).

To implement the model requires knowledge of the aerosol characteristics (Activity Median Aerodynamic Diameter, AMAD, geometric standard deviation, σ_g) and the absorption of the material from lung to blood. It is recommended that the actual values should be used when they are known; however, default values are also given. For members of the public, the default AMAD is 1 μm and for workers it is 5 μm. For absorption, it is recommended that material-specific rates should be used for compounds for which reliable human or animal experimental data exist. For other compounds, default values are recommended according to whether the absorption is considered to be fast (Type F), moderate (M) or slow (S).

The model describing the biokinetic behaviour of uranium once taken up into blood following either ingestion or inhalation is described in ICRP Publication 69 (1995a). It is based on the generic model structure for alkaline earth elements (ICRP, 1993), since uranium tends to follow the qualitative behaviour of calcium to a large extent with regard to skeletal kinetics.

These models are used to calculate dose coefficients for intake by members of the public and workers. For members of the public, dose coefficients for ingestion are given for ages : 3 months, 1 year, 5 years, 10 years, 15 years and adults. The gastro-intestinal uptake factor (f_1) used is 4×10^{-2} for 3-months of age and 2×10^{-2} for all other ages. These values apply to all uranium compounds. The dose coefficients are given in ICRP (1995a). For members of the public, dose coefficients for intake by inhalation are given for the same age groups in ICRP Publication 71 (1995b). In the case of inhalation, it is necessary to give consideration to likely chemical forms of the inhaled material and how this might affect its assignment to the Absorption Type. Default Type M is recommended for use in the absence of specific information.

Dose coefficients for intakes of radionucldies by workers are given in ICRP Publication 68 (1994b). For inhalation, compounds corresponding to all three Absorption Types may be present in the work place. Table 1 compiles the recommendations that are made.

For ingestion in the workplace, the following values of f_1 are recommended: unspecified compounds, 0.02; most tetravalent compounds, 0.002.

In all cases, dose coefficients are given for each uranium isotope separately. It is thus possible to combine these values to obtain dose coefficients for specific materials, e.g. natural, enriched or depleted uranium, once the isotopic composition is known. An example based on ICRP default Type S is given in Tables 2 and 3

Table 1
Recommended absorption types

Compounds	Type	f_1
Most hexavalent compounds e.g. UF_6, UO_2F_2 and $UO_2(NO_3)_2$	F	0.02
Less soluble compounds e.g. $U0_3$, UF_4, $UC1_4$ and most other hexavalent compounds	M	0.02
Highly insoluble compounds e.g. UO_2 and U_3O_8	S	0.002

Table 2
Composition of uranium

		^{234}U	^{235}U	^{238}U	Specific activity ($Bq\ mg^{-1}$)
Natural	% mass	0.05	0.72	99.2	25.2
	% activity	48.9	2.2	48.9	
Depleted	% mass	0.001	0.2	99.8	14.8
	% activity	15.5	1.1	83.4	

Table 3
Example values for DU, 5 μm, Type S. Intake by inhalation

Dose coefficient	$5.6\ 10^{-6}\ Sv\ Bq^{-1}$
Intake to give 20 mSv	3.4 kBq or 230 mg

below, but it is important to remember that ICRP advises on the use of material-specific values where these are known. This has been done in the Royal Society Report (2001).

3. Monitoring after intake

DU emits very little penetrating radiation (e.g. γ-rays) that would be able to escape from the body. Therefore monitoring by direct methods, such as lung counting would only be feasible following very large intakes, which are unlikely to occur. Biological monitoring would therefore need to be based upon analysis of excreta, usually urine. Some information to assist with interpretation of urinary excretion is given in ICRP (1997). However, it must be remembered that uranium exists naturally in the environment and hence in our diets. So we all have some uranium in our bodies and in our urine. Therefore sensitive means of isotopic analysis are required if intakes of depleted uranium are to be distinguished from normal dietary intakes.

4. Conclusion

We hope this short resumé of ICRP advice on uranium will enable your readers to identify and make use of ICRP recommendations. However, we would reiterate that where material-specific values are available they should be used in the models. If it is assessed that intakes of DU may be significant, i.e. lead to significant radiation doses or the risk of chemical toxicity, then we would recommend that experiments should be carried out to determine the relevant parameter values.

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